Update to TSO-C161a Regarding Airborne Constraint Region and Test Message
6/3/2018

Since the publication of TSO-C161a on Dec 17, 2009, the international aviation community has further restricted the allowable airborne constraint regions of both double delta and early-minus-late correlators as documented in working paper NSP May15 /WGW/WP 28 at the Navigation Systems Panel Working Group Meeting, May 15-17, 2012. RTCA incorporated these changes in the allowable airborne user constraint region in RTCA DO-253D, *Minimum Operational Performance Standards for GPS Local Area Augmentation System Airborne Equipment*, dated July 13, 2017. The first two changes below list the relevant requirements from DO-253D.

However, RTCA also discovered an error in a message used for testing. DO-253C included a test to ensure the Position and Navigation (PAN) function properly processes messages in the event the synchronization and ambiguity resolution segment of the training sequence happens to occur within the application data portion of the transmitted VDB message. RTCA identified the test message provided in Table 2-26 is in error since the defined test is not functional. The Table in DO-253D is also in error as stated in the third listed change.

Changes

In order to reflect the reduction in the allowable airborne user constraint region and use of correct test message, the following changes are necessary when using TSO-C161a:

1) Replace section 2.3.6.4.1 of RTCA DO-253C with the following:

2.3.6.4.1 GPS Tracking Constraints

GPS satellites shall *[LAAS-303]* be tracked using either an early-minus-late or double delta delay lock loop discriminator.

For early-minus-late (E-L) delay lock loop (DLL) discriminator tracking of GPS satellites, the pre-correlation bandwidth of the installation, the correlator spacing (d), and the differential group delay shall *[LAAS-091]* be within the ranges as defined in Table 2-6 for the applicable GAEC and illustrated in Figure 2-3.

Table 2-6 GPS Tracking Constraints for E-L DLL Discriminators

Region (see Figure 2-3)	3 dB Pre-correlation bandwidth, BW	Average Correlator Spacing (d) [C/A chips]	Instantaneous Correlator Spacing (d) [C/A chips]	Differential Group Delay	Appli-cable GAEC
1	4<BW≤7 MHz	0.045-0.21	0.04-0.235	≤ 600 ns – D_A – D_C	C
2	7<BW≤16 MHz	0.045-0.21	0.04-0.235	≤ 150 ns – D_A – D_C	C & D
3	16<BW≤20 MHz	0.045-0.12	0.04-0.15	≤ 150 ns – D_A – D_C	C & D
4	20<BW≤24 MHz	0.08-0.12	0.07-0.13	≤ 150 ns – D_A – D_C	C & D

Note: D_A *is the differential group delay contribution of the antenna through the output of the pre-amp.* D_C *is the differential group delay contribution of the installation specific connection between the antenna and the PAN equipment.*

Note: Region 4 is not practical for airborne equipment that also track SBAS ranging signals when implemented using a common receiver front end for receiving the GPS and SBAS signals. This is because the SBAS tracking constraints given in Table 2-9 do not include bandwidths in Region 4 of Table 2-6.

The instantaneous correlator spacing is defined as the spacing between a particular set of early and late samples of the correlation function. The average correlator spacing is defined as a one-second average of the instantaneous correlator spacing. The average applies over any one-second time frame.

The discriminator (Δ) shall [LAAS-092] be based upon an average of early-minus late samples with spacings inside the specified range. Either a coherent or a non-coherent discriminator may be used.

For Double Delta (DD) DLL discriminators of the type $\Delta=2\Delta_{d1} - \Delta_{2d1}$ tracking GPS satellites, the pre-correlation bandwidth of the installation, correlator spacings (d_1 and $2d_1$) and the differential group delay shall *[LAAS-093]* be within the specified ranges as defined in Table 2-7 for the applicable GAEC and illustrated in Figure 2-3. Either a coherent or a non-coherent discriminator may be used.

Note: These tracking constraints for DD DLL discriminators are different than the tracking constraints contained in DO-229() and DO-316().

Table 2-7 GPS Tracking Constraints for DD DLL Discriminators

Region (see Figure 2-3)	3 dB Pre-correlation bandwidth, BW	Average Correlator Spacing (d_1 and $2d_1$) [C/A chips]	Instantaneous Correlator Spacing (d_1 and $2d_1$) [C/A chips]	Differential Group Delay	Applicable GAEC
1	(-50*x)+12 <BW≤7 MHz	0.1-0.16	0.09-0.18	≤600 ns $-D_A - D_C$	C
	4<BW≤7 MHz	0.16-0.6	0.14-0.65		
2	(-50*x)+12<BW≤ (133.33*x)+2.667 MHz	0.07-0.085	0.063-0.094	≤150 ns $-D_A - D_C$	C & D
	(-50*x)+12<BW≤14 MHz	0.085-0.1	0.077-0.11		
	7<BW≤14 MHz	0.1-0.24	0.09-0.26		
3	14<BW≤16 MHz	0.1-0.24	0.09-0.26	≤150 ns $-D_A - D_C$	C & D
	14<BW≤ (133.33*x) +2.667 MHz	0.085-0.1	0.077-0.11		

Notes: (1) In the pre-correlation bandwidth column, x denotes the average correlator spacing.

(2) D_A *is the differential group delay contribution of the antenna through the output of the pre-amp.* D_C *is the differential group delay contribution of the installation specific connection between the antenna and the PAN equipment.*

The differential group delay, which applies to the entire aircraft installed system, including that of the antenna (D_A), any installation specific cabling or active devices (D_C), and the RF front end of the PAN, must be bounded. However, there is some flexibility in the apportionment of differential group delay among these components.

If the equipment uses an RTCA/DO-301 minimum standard compliant antenna, D_A is 25 ns. If the equipment uses a specific RTCA/DO-301 compliant antenna, it may take advantage of any reduced differential group delay (i.e., D_A may be < 25 ns).

In addition, an aircraft installation consisting of only cable and connectors may be assumed to have a differential group delay contribution (D_C) of 0 ns. However, installations incorporating devices such as splitters or amplifiers may introduce additional differential group delay. The manufacturer may support such installations, but has no obligation to do so. In any event, the manufacturer must specify the maximum acceptable installation related differential group delay (D_C). This limit should be defined in the installation instructions.

Note: Equipment built to earlier versions of the document are assumed to support only $D_C = 0$. *The original receiver requirements derivation included no installation allocation.*

The differential group delay is defined as:

$$\frac{1}{360} \cdot \left| \frac{d[\Phi(f_1)]}{df} - \frac{d[\Phi(f_2)]}{df} \right|$$

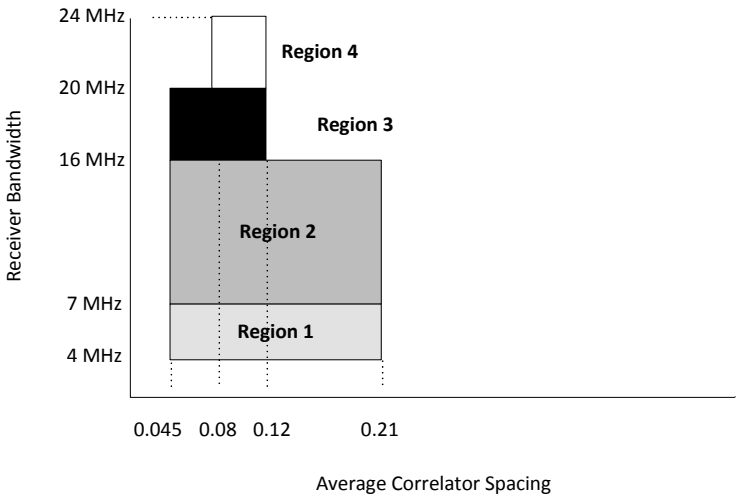
where:

f_1 and f_2 are any frequencies within the 3 dB bandwidth of the pre-correlation filter.

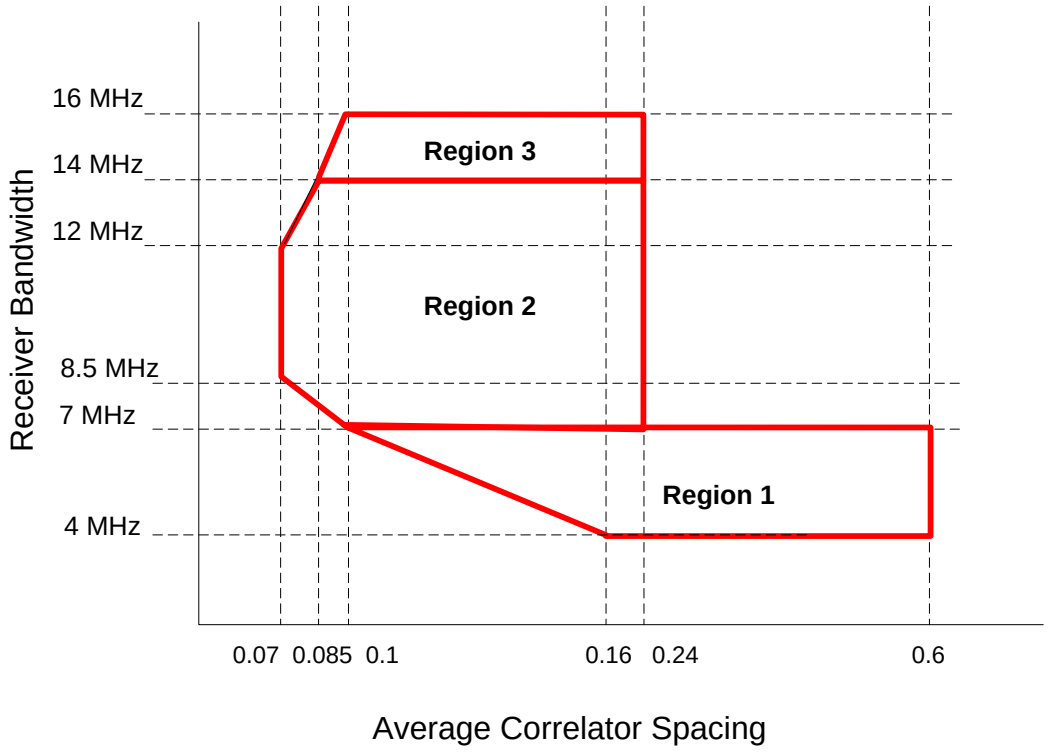
$\Phi(f)$ is the combined phase response of the equipment in degrees (excluding the antenna).

f is the frequency in Hz.

For the DD DLL discriminators, the pre-correlation filter shall *[LAAS-304]* roll-off by at least 30 dB per octave in the transition band which starts at the -3dB points, and the resulting attenuation in the stop band shall *[LAAS-396]* be greater than or equal to 50dB (relative to the peak gain in the pass band) at frequencies more than 24 MHz from the band center.



E-L Discriminator Tracking of GPS Satellites



DD Discriminator Tracking of GPS Satellites

Figure 2-3 Receiver Bandwidth vs. Average Correlator Spacing

Note: The technical implementation of the airborne receiver must be constrained to enable the LAAS ground system to effectively protect the airborne receiver from possible degradations in the GPS satellite signal. These constraints are described in terms of correlator spacing, receiver

bandwidth and receiver differential group delay. The satellite signal degradations considered in developing these constraints included:

a) Distorted satellite signal causing multiple correlation peaks

b) Correlator peak distortion due to code coherent spurious signals (such as reflected signals or code transition induced wave forms in the satellite)

c) Code coherent spurious signals distorted by RF filter differences

d) Flat correlation peaks causing excessive noise or drift

e) Discriminator behavior based on transient distorted satellite signal conditions.

2) Delete Item 2 in Appendix 1 of TSO-C161a.

3) Modify the test message for Section 2.5.2.2.5.4 as follows:

While the test procedures and the corresponding requirements are correct, the test message contains an error in Table 2-26. At this time, we do not have a validated test message for inclusion in the MOPS or in this TSO. Therefore, you must develop your own test message for use with the detailed test procedure defined in DO-253C Section 2.5.2.2.5.4 *Training Sequence and Message Failure Rate Test.*

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